THE DESIGN AND CONSTRUCTION OF A

SOFT COAL GAS PRODUCER

A THESIS

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OF A SOFT COAL GAS PRODUCER.

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In the field of the gas producer, as in the whole field of engineering to-day, that which all designers and operators are working to obtain is the maximum of reliability coupled with the minimum of operating expense. Compromises are constantly be made between these aims, for frequently that mechanism which is the least expensive to operate can not be depended upon to do its duty at all times.

Many producers for the use of anthracite coal have been designed and operated with so much success and with such a saving in the daily expenditure, both for fuel and attendence that they are gradually supplanting the boiler and furnace in stationary practice. As this is being done even while using the more expensive kind of coal, it must be evident to all those interested, that when the same grades of coal can be used that are now consumed in the average furnace, the demand for the gas producer will even more rapidly increase. Owing, however, to the difficulty of removing products of tar from the gas, formed by the combustion of bituminous coal, producers of this type have, as yet, little or no commercial value; for these substances so cling to the surfaces of the apparatus in which the gas

is burned that the use is rendered impracticable.

In most of the experiments conducted up to the present time, the plan has been to take care of these products by some mechanical means. But, as all these attempts have met with only partial success, it is our object to design and construct a producer that will remove these substances in another way; namely, by causing them to become converted into fixed gases, which object, we are confident, can be accomplished if they are heated to a sufficient temperature.

To do this, we are constructing a producer along lines which will now be described in detail, reference being made to the accompanying prints. It will, of course, be understood that this piece of apparatus is for experimental purposes and that many changes would be made in any that were for commercial use.

The outside shell of this producer is built up of cast iron sections, such as are shown in a groove in the top edge of the one just below it. A pan, also made of cast iron and shown in Fig. 1, forms the bottom part of the apparatus and upon it rests the brick work which supports the cast iron sections and forms the lining of the two chambers of the producer. These bricks are laid up in fire clay, just enough of being used to insure a tight joint. Upon the upper edge of the top section is placed the large

plate, a drawing of which is given in Fig. 3, and upon the upper face of this flanges have been cast which form cups of rectangular cross section in which the sides of the top covers rest. This plate is held to the section below it by being cemented with smooth-on. The object of the large pan at the base of the cups on the top plate is that the producer may be water sealed, both at the bottom and at the top, by simply filling them to the required depth. Pipes have been connected to these receptacles so that they may be filled when desired. The water may be drawn from the large pan into a nearby sump by the use of a siphon, and the desired level is maintained in the upper seal by an adjustable overflow, which empties into the lower pan. Three courses of brick have been left out at the very bottom of each end, and across the openings thus formed the plates, shown in Fig. 4, have been placed to support the brick work above. The object of these openings is that a place for removing the ashes may be afforded. A two-inch pipe, which can be connected by means of a union to another pipe accessible to the outside air, passes through one of the covers. This pipe affords a passage for the gases when the producer is not in use, and may be disconnected and plugged when the producer is in operation.

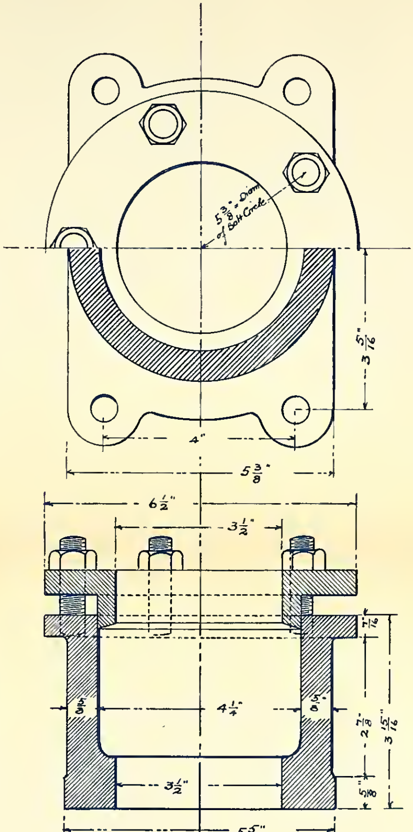
A much better idea of the construction described

above will be obtained if the reader will refer to the assembled drawings given in Fig. 8 and 10; for in these all the parts are clearly shown with letter of reference which are explained by the following table:

A and A'	The air valves constructed as shown in the detail given in Fig. 7.
B and B'	Gas valves exactly the same design as A and A'.
C and C'	T fittings through which the air enters and the gas leaves the producer. The plugs may be removed by cleaning the valves and the pipe (G).
D and D'	Check valves on air line to prevent the flame from coming out into the room in case of an explosion.
E and E'	Stuffing boxes, constructed as in the detail shown in Fig. 6. Asbestos rope packing is used. Their object is that the pipe G may be withdrawn and replaced when it is desired to clean it without disturbing the brick.work.
F	4" pipe leading to scrubber (See assembled drawing, Fig. 10.)
G and G'	3" pipes filled with holes varying in sizes from 3/4" to 1-1/8" in diameter, the smaller holes being placed nearest the T fitting so that an approximately equal suction will be maintained across each chamber. The sum of the areas of the holes is equal to the area of the cross section of the pipe.
H and H'	Covers of the two chambers of the producer.
I and I'	Peak-holes in which thick pieces of isinglass are held between screw caps.

The letters marked(') are not shown but are symmetrically located with reference to the vertical axis of the producer.

FIGURE No.6



DETAIL OF STUFFING BOX.
Scale 6" = 1' - 0"

Thesis of Messrs Burge, Loofbourrow, and Perkins.

Thesis of Messrs Burge, Loofbourrow, and Perkins.

FIGURE No. 10

SCHEME OF CONNECTIONS OF APPARATUS USED.

A ~ PRODUCER.

B ~ SCRUBBER.

C ~ 7 H.P. FAIRBANKS MORSE GAS ENG.

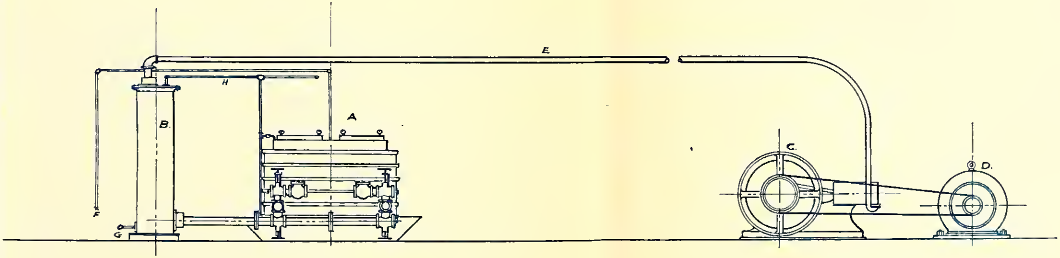
D ~ 10 H.P. MOTOR.

E ~ $2\frac{1}{2}$" DELIVERY PIPE.

F ~ $\frac{1}{2}$" STEAM PIPE.

G ~ 1" DRAIN "

H ~ $\frac{1}{2}$" WATER SUPPLY.



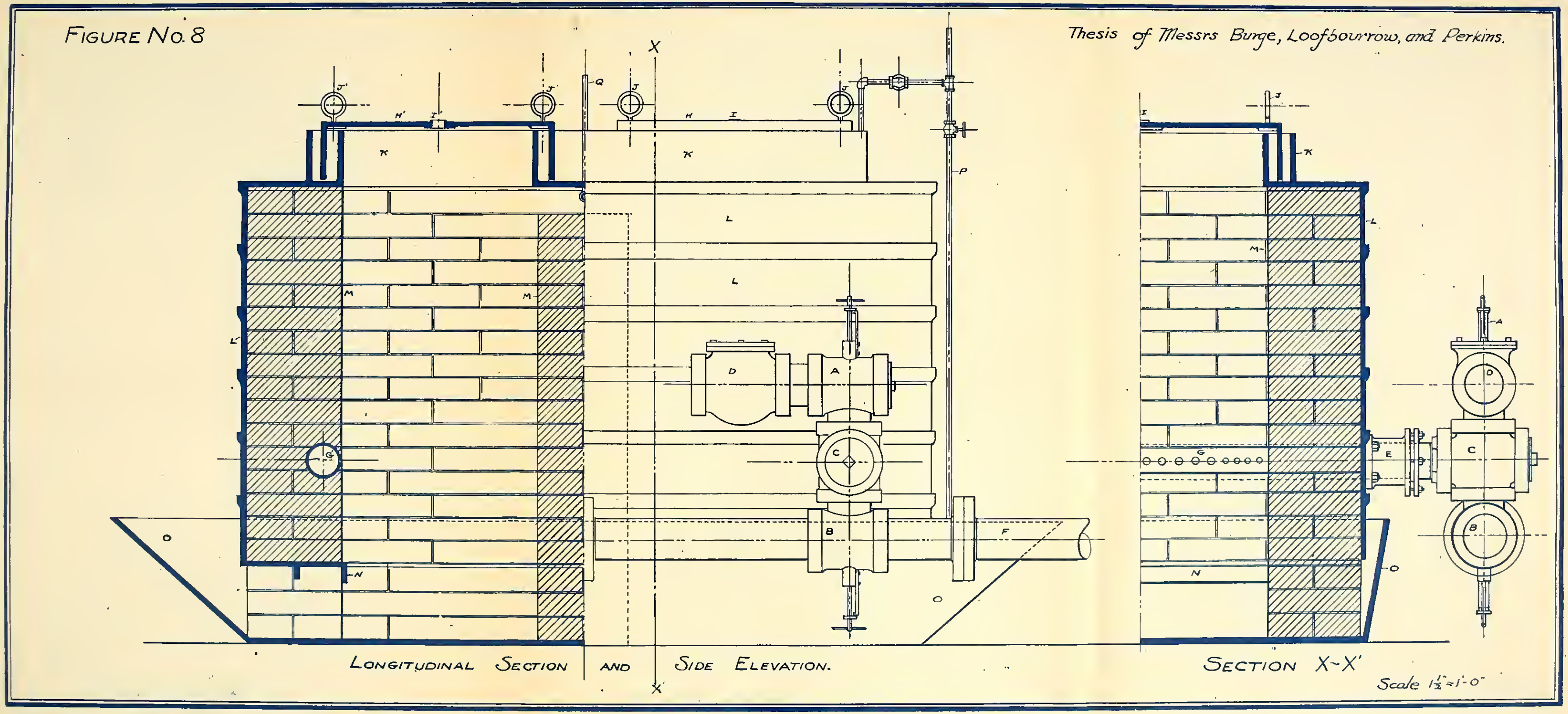


FIGURE No. 8
Thesis of Messrs Burge, Loofbourrow, and Perkins.
LONGITUDINAL SECTION AND SIDE ELEVATION.
SECTION X~X'
Scale 1½"=1'-0"

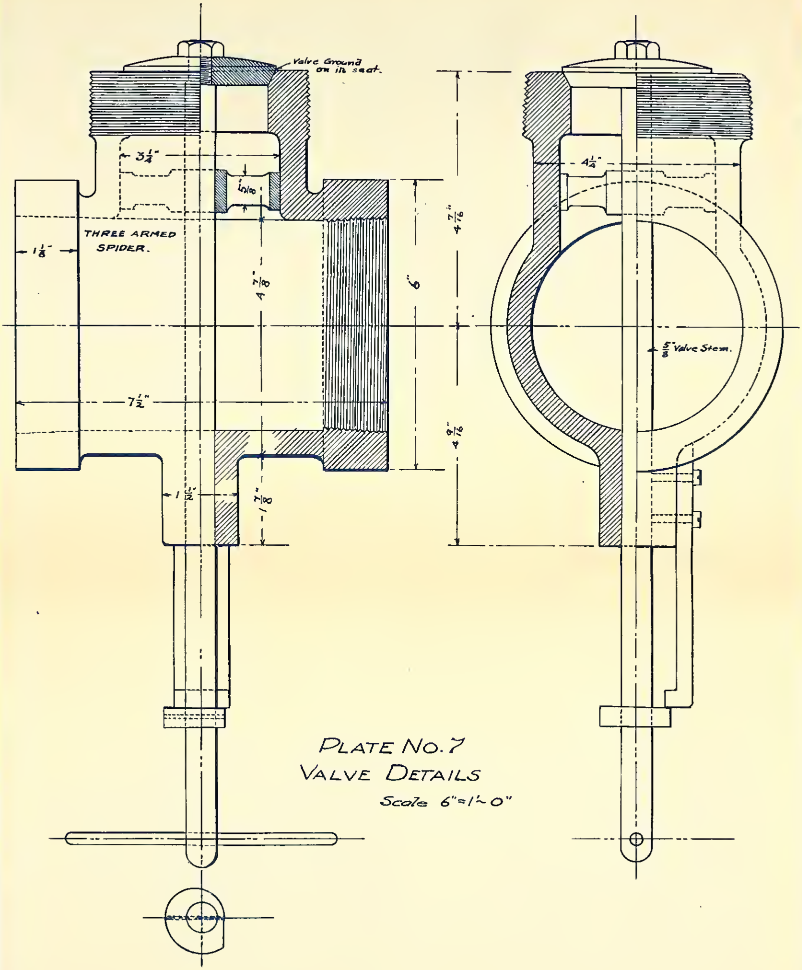


PLATE No. 7
VALVE DETAILS
Scale 6" = 1'-0"

Thesis of Messrs Burge, Loofbourrow, and Perkins.

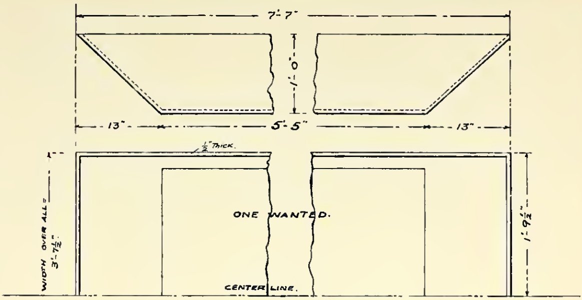


Figure No. 1

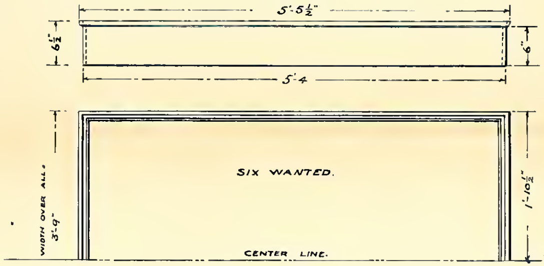


Figure No. 2

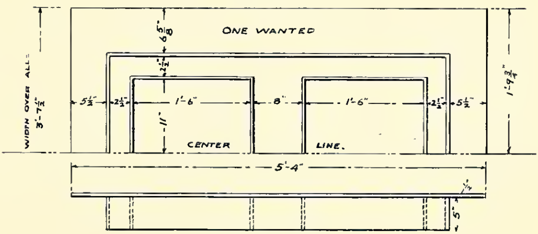


Figure No. 3

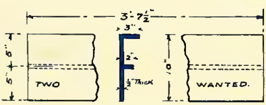


Fig. No. 4

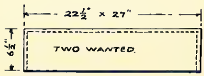


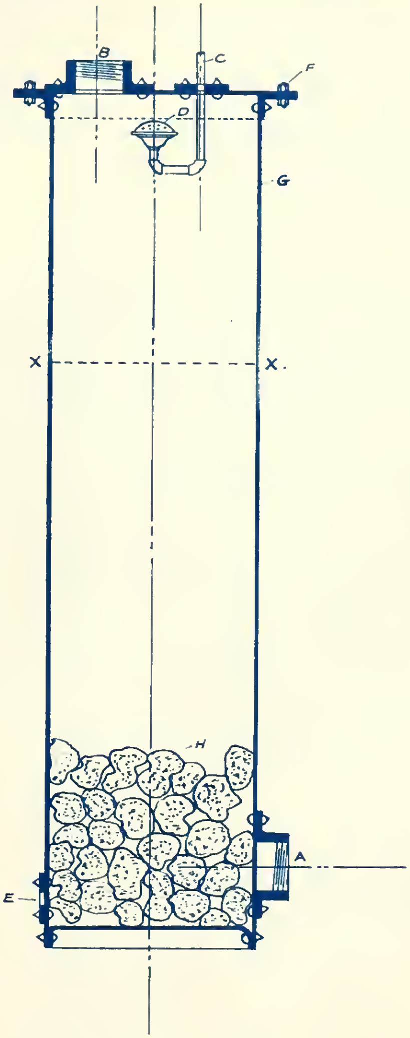
Fig. No. 5

Details.

Scale 1" = 1'-0"

Thesis of Burge, Loofbourrow, and Perkins.

FIGURE No. 9



SECTION THROUGH SCRUBBER.

Scale 1" = 1'-0".

J and J'	Rings for lifting covers
K	Flanges forming water seal
L	Cast iron sections of shell
M	Fire brick lining
N and N'	Plates which support and brick
O	Base pan forming water seal
P	1/2" pipe through which water is supplied to the two water seals
Q	A 1/2" pipe supplying steam to the producer

Referring to the section of the scrubber shown in Fig. 9:

A	is a 4" circular flange to which pipe from producer is attached
B	is a 4" flange for attaching pipe to engine
C	1/2" pipe through which water is supplied to the scrubber.
D	Sprayer
E	Plate tapped for 1" drain pipe, which, by the way, is bent in the form of a U tube to form a water seal for the scrubber.
F	3/8" bolts holding head to flange
G	3/16" tank steel
H	Coke filled in producer to x - x .

The theory of construction and the method of operation of the producer are rather simple and may be taken up together as follows:

With all the valves (AA', BB') wide open a fire is kindled in both sides of the producer and the motor is started, thus causing the engine to work as a pump, producing a vacuum in the producer. When a cone of ashes has formed nearly to the delivery pipes the furnaces are filled to the required depth with bituminous coal, and the water seals are filled, which makes the producer now ready for operation.

The first step necessary in the manufacturing of the gas is now to close the air valve on the side in which the best fire is known to exist and close the gas valve on the opposite side leaving the other two valves open. The next step is to turn on just the proper amount of steam, this amount being determined experimentally, as too much will kill the fire, and too little will keep the gas from having the proper amount of hydrogen to give it "snap"

If out theory is correct the producer will now be delivering good gas for the air, after entering the first chamber, will pass up through the burning coal where the oxygen contained in it will be converted into CO_2 as shown by the chemical equation $C + O_2 = CO_2$

Next, this hot gas, coming in contact with the intensely heated carbon is changed to CO as is indicated in the equation.

$$\text{Heat} + CO_2 + C = 2\,CO$$

The conditions up to this point are exactly similar to those in the hard coal producer, but now the gas comes in contact with the volatile matter, which is driven of at comparatively low temperatures, and which, up to the present time, has been the cause of all the troubles found in the use of bituminous coal. The CO now mixes with the vapor and with the steam, the latter being converted into free hydrogen and CO as it is drawn down through the hot bed of coal in the second chamber of the producer. The equation for the change is

$$\text{Heat} + H_2O + C = CO + H_2$$

and, as no oxygen can enter this side of the producer with the valves in their present position, these gases cannot be again changed to CO_2 and H_2O.

The volatile tarry products which are composed of high hydro-carbons are broken down into those of simpler order such as C_2H_2, etc. The composition of tar will run approximately

Crude Naptha	5 to 8 per cent
Heavy oils	25 to 30 per cent
Anthracene oils	8 to 10 per cent
Pitch	50 to 55 per cent

As the fire in either of the furnaces could burn only for a short time with oxygen present, it will be necessary at frequent intervals to reverse the direction of flow of the gas through the producer, thus causing the one

which has been furnishing the gas to become the purifier and the other one to become the producer.

To make this change it is first necessary to close the air valve that is now open, next open the gas valve that is now closed, then close the gas valve that was formerly open, and finally open the air valve that before was closed. These changes must be made as rapidly as possible and in the order named, for it will readily be understood that any other would be certain to cause an explosive mixture of air and gas to be formed, either in the producer itself or in the gas line, which would cause inconvenience through the blowing out of the water seal if nothing of greater consequence.

It might not be out of place to show here the way in which heat affects the hydrocarbons, taking, for instance, Pentane as an example. The formula for pentane being C_2H_{12}, we may represent this as

$$\begin{array}{ccccccccccccc} & & H & & H & & H & & H & & H & & \\ & & | & & | & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & | & & | & & \\ & & H & & H & & H & & H & & H & & \end{array}$$

Now when heat is added this may be broken down in a number of ways, such as:

$$\begin{array}{ccccccccccccccccc} & & H & & H & & & & & & H & & H & & & & \\ & & | & & | & & & & & & | & & | & & & & \\ H & - & C & - & C & - & H & + & H & - & C & - & C & - & H & + & C \\ & & | & & | & & & & & & | & & | & & & & \\ & & H & & H & & & & & & H & & H & & & & \end{array} = 2\ C_2H_6 + C$$

or as

$$\begin{array}{c} H \\ | \\ H - C - H \\ | \\ H \end{array} + \begin{array}{c} H \\ | \\ H - C - H \\ | \\ H \end{array} + \begin{array}{c} H \\ | \\ H - C - H \\ | \\ H \end{array} + 2C = 3CH_4 + 2C.$$

The carbon, in every case, being in the form of lamp black.

The compound that will be formed depends upon the degree of heat supplied.

In submitting this thesis, we wish to thank Prof. H. B. MacFarland for his many helpful suggestions as to the design of the producer, and to state that to him is due the credit for the idea upon which it is constructed.